Fuels

The fuel assessment layer exemplifies the local fire hazard situation. The fuels assessment is a very useful tool in assisting pre-fire planners and fire safe councils target critical areas for fuel treatment.

This assessment evaluates current flammability of a particular fuel type, given location on the slope, average bad weather conditions, surface and ladder fuels, and crown density.

Fuel, in the context of wildland fire, refers to all combustible material available to burn within a given area of land. Grass, brush and timber are the most common fuels found in the Sierra Nevada ecosystem. Each fuel has its' own burning characteristics based on several inherent factors. These factors include moisture content, volume, live to dead vegetation ratio, size, arrangement and the plant's genetic make up. All of these contribute to a fires spread, its intensity, and ultimately, its threat to assets.

Fuel loading is measured in tons per acre. Grass is considered a light fuel with approximately ¾ of a ton per acre. On the other end of the spectrum, thick brush, a heavy fuel, can have a volume of over 21 tons per acre. Fire intensity is also directly related to fuel loading. Grass burns rapidly with a short period of intense, maximum heat output. Brush, on the other hand, has a long sustained high heat output making it more difficult to control. With this in mind it is prudent to identify areas containing heavy concentrations of fuel and target these areas for hazard reduction.

HAZARDOUS FUELS ASSESSMENT

Fuel arrangement is critical in wildland fire behavior, as it is linked to how readily the fuel burns and hence a fires spread. Un-compacted fine fuels, such as grass, spread fire rapidly since more of its surface can be heated at one time. Compacted fuels, such as pine litter, on the other hand burn slower because heat and air only reaches the top of the fuel. Vertical arrangement refers to the continuity of fuel from the forest floor to the tree canopy. The vertical arrangement of fuels is known as ladder fuels; they are an extremely influential factor in fire spread and behavior often turning a ground fire in to a crown fire. Crown or

canopy closure refers to the density of a forest created by tree tops, and is very important in the lateral progression of fire through the forest canopy.

In an attempt to estimate fire behavior, the U.S. Forest Service has developed 13 fuel models that categorize fuels by their burn characteristics shown in the table below. Four general groups, also known as planning belts, are used to classify fuels: grass, brush, timber and logging slash. The following is a brief description of the fuel models commonly found in CDF's wildland protection area of Butte and Plumas Counties:

Source material: Anderson, Hal E. 1982 Aids to Determine Fuels Models For Estimating Fire Behavior. United States Department of Agriculture, Forest Service. General Technical Report INT-122. Ogden Intermountain Range and Experiment Station) and Harrell, R. D. "Dick" & Teie, William C. 2001 Will Your Home Survive? A Winner or Loser? A guide to help you improve the odds against Wildland Fire. Deer Valley Press

Fuel Model 1: This model is used for short (generally below knee level or about 1-foot tall) fine-textured pure grass which best represents typical grasslands and savannas. Less than one-third of the area has other vegetation like shrubs or trees. Fuel loading in fuel model 1 range from ½ to ¾ of a ton per acre. Fires in fuel model 1 burn rapidly with flame lengths averaging 4 feet. This is probably the most common fuel model within the Butte Unit, reflective of nearly all of the grasslands found in the eastern foothills of Butte County below an elevation of approximately 1000 feet.

Fuel Model 2: Like fuel model 1, fuel model 2 is dominated by grass about 1 to 2-feet tall, usually under an open wooded or timber over-story. The larger particle size in these shrubs and the litter from the tree over-story increases intensity, but reduces fire spread. Four to five tons of fuel is found per acre and the fuel bed depth is 1-2 feet. This type of fuel can be found in the foothills east of Chico and Oroville, Palermo, and in the eastern portion of Plumas County.

Fuel Model 4: This is a brush model and is characterized by stands of mature brush 6 feet or more in height with continuous, inter-linking crowns, and ranging from 15 to 80 tons per acre. Fires in this fuel model burn intensely (50+ foot flame lengths) and spread relatively quickly. This fuel type is found in some areas of the Big Chico canyon, Cohasset, and in the southern and eastern portions of Lake Oroville.

Fuel Model 5: Fuel model 5 is composed of the same mixes of vegetation as Fuel Model 4, but individual plants are shorter, usually sparser, and less mature with little or no dead component. This model occurs on poor sites, on recent burns and may occur under tree over-stories. Fires in this fuel type do not burn as intense (6-13 foot flame lengths), nor rapidly due to higher concentrations of live to dead fuel. This fuel type is common at about the 2000 to 3000 foot elevation in northern foothills Butte County.

Fuel Model 6: This fuel model consists of vegetation which is taller and more flammable than that of fuel model 5, but not as tall or as dense as fuel model 4. Fires in this model will burn in

the foliage of standing vegetation, but only when wind speeds are greater than 8 mph. Fires burn with an average flame length of 6 feet and spread at a rate of 2,112 feet/hour. Interior live oak, young chamise and manzanita are all associated with this fuel model. In many instances a fuel model 5 will evolve into a fuel model 6 by the latter part of summer. This fuel type is found in the Paradise, Concow, Berry Creek, and Feather Falls areas.

Fuel Model 8: This model reflects slow burning, low intensity fires burning in the leaf or needle litter under a conifer or hardwood canopy. Fuel model 8 contains few fine fuels (about 1-2 tons per acre) consisting of compacted leaf and short needle conifer litter and is absent an under story shrub layer. These fires do not pose a threat unless low fuel moisture or high winds allow the fire to spread into the canopy. This model is found locally in areas treated for fuel reduction. It represents the ideal model; where fire behavior is characterized by low-intensity, slow burning ground fire. This type of vegetation is fund primarily in the southwest area of Oroville in the Oroville Wildlife Area, and scattered throughout Plumas County with heavy concentrations in the Bucks Lake, LaPorte, and southwest of Johnsville.

Fuel Model 9: Much like fuel model 8 this model has little or no shrub layer but has more fine fuels (about 2-4 tons per acre) which is deeper and "fluffier" like oak leaves and long conifer needles. Fires in this model also burn with more intensely and higher rates of spread especially under windy conditions. This model is found in a wide range of areas under timber stands which have been treated for fuel reduction, or have seen low intensity fires over the last decade. This fuel type is found in great quantities in the 2,500 to 4,000 foot elevation of eastern Butte County from Butte Meadows south to Feather Falls. Fuel Model 9 is also extremely prevalent throughout Plumas County, but most notably along the highway 70 corridor. Surface fire flame lengths, without the affects of wind or slope, range from 3 to 7 feet.

Fuel Model 10: Fuel model 10 almost always has a shrub or immature tree under story with loadings of fine fuels of about 3 to 4 tons per acre and heavy loadings of 12+ tons per acre. Fires in this timber model burn with greater intensity (6-10 foot flame lengths) with moderate rates of spread. Torching of individual trees is common and can cause embers to start new "spot" fires ahead of the main fire. Crown fires are also a threat in this fuel type. In dry conditions, or with high winds, fires in fuel model 10 can be very difficult to control. This model is characterized by stands of overstocked, unmanaged natural conifer stands, and can be found in many areas of Butte and Plumas Counties.

Fuel Model 11: Fuel model 11 is either the felled boles of a thinned stand or the limbs and tops from a logging operation. Recently deposited slash ("red slash") may be 3+ feet deep and will have about the same burning characteristics as Fuel Model 4. Aged slash will likely burn more like Fuel Model 10. Loading is about 12 tons-per-acre and the fuel bed depth is about 1-foot.

Fuel Model 12: Fuel model 12 is dominated by slash, much of it is less than 3 inches in diameter with fuel loads less then 35 tons/acre. Heavily thinned conifer stands, clearcuts, and

medium or heavy partial cuts are represented. Fire in this fuel model typically spread rapidly with high intensity and generate fire bands which often results in spot fires.

Fuel Model 13: Similar to fuel model 12, however fuel model 13 is dominated by slash, much of which is larger than 3 inches in diameter with fuel loads greater then 35 tons/acre and may exceed 200 tons/acre. Characterized by clear cuts and heavy partial cuts in mature and over-mature stands of conifer. Fire in this fuel model typically spread rapidly in the fine fuels while intensity builds up more slowly and sustains for longer periods in the larger fuels. A wide variety of fire bands often contribute to spotting problems.

National Wildfire Coordinating Group Fuel Models
Butte Unit Description

Fuel Model #	Fuel bed depth (feet)	Tons per acre (live)	Tons per Acre (dead)	Flame Length (feet)	Spread Rate (feet/hour)	Comments
1	1	0	.74	4	5195	Dry grass. Common in areas under 1000' elevation.
2	1	.5	4	6	2331	Dry grass with 1/3 to 2/3 brush or tree canopy. Very common above 1000'.
3	2.5	2.5	3.01	12	6926	Grass model, not found locally.
4	6	5.01	16.03	19	4995	Thick brush with heavy dead component.
5	2	2	3.5	4	1199	Young or green brush with fire in the litter only.
6	2.5	2.5	6	6	2131	Mature or dry brush with foliage that will burn when exposed to wind.
7	2.5	2.5	4.87	5	1332	Brush model, not found locally.
8	.2	.2	5	1	107	Timber or hardwood with fire burning in light litter underneath. No shrub.
9	.2	.2	3.48	2.6	499	Timber with fire in slightly heavier litter then model 8
10	1	1	12.02	4.8	526	Timber with shrub/immature tree understory, heavy dead material underneath.
11	1	1	11.52	3.5	400	Light logging slash from a partial thinning operation
12	2.3	2.3	34.57	8	866	Moderate logging slash
13	3	3	58.1	10.5	899	Heavy logging slash

Shading denotes those fuel models predominant to Butte and/or Plumas Counties.

The local distribution of the fuel models is illustrated in the above table. It can be noted that the diversity of combustible material, both in terms of species and arrangement, increases with elevation. Models 1 and 2 (grass fuel models) are found at lower elevations up to about 1,500 feet, progressing into brush and from their timber at the 2,300 foot elevation generally. Local conditions, known as micro-climates also affect fuel type and density. For instance, north facing slopes tend to get slightly more rainfall and less sun favoring the development of hardwood and succulent species. In contrast, southern exposures are dominated by brush and conifer species which have adapted to drier, poor soil conditions.

The first step in defining hazardous fuels is the development of a vegetation coverage layer for the Butte Unit using GIS. Planning belts have been established to categorize the 13 various fuel types in to four general areas (grass, brush timber, and woodland) consisting of similar fuels. Moreover, these zones have similar fire behavior characteristics that impact fire suppression activities, and are based on the Fire Behavior Prediction System (FBPS) fuel modeling correlation.

The vegetation within the planning belts is then categorized into the FPBS fuel model coverage as described in the National Wildfire Coordinating Group Fuel Models on the previous page. After the vegetation coverage was completed, ArcGIS was used to display the vegetation coverage overlaid with the unit's fire history. Through analysis, the impact on surface fuel characteristics as a result of past fires was factored into the creation of a final vegetation layer. The final product is a more accurate account of the current "post fire" vegetation coverage's throughout the unit, and thus, FBPS fuel characteristics.

The final phases of determining fuel hazard ratings for Butte Unit involves the combining of crown fuel characteristics and surface fuel characteristics. The method describes additional ladder and crown fuel indices to surface fuels in a given area. If the vegetation data provide sufficient structural detail, the method imputes these additional indices from that data. If the vegetation data lacks structural detail, the method imputes indices based on the fuel model. In the Butte Unit, the majority of indices were based on the FPBS fuel models.

Where applicable, the ladder and crown fuel indices convey the relative abundance of these types of fuels. The indices take values ranging from 0 to 2, with 0 indicating "absent", 1 representing "present but spatially limited", and 2 indicating "widespread". These indices indicate the probability that torching and crown fire will occur if the stand were subjected to a wildfire under adverse environmental conditions.

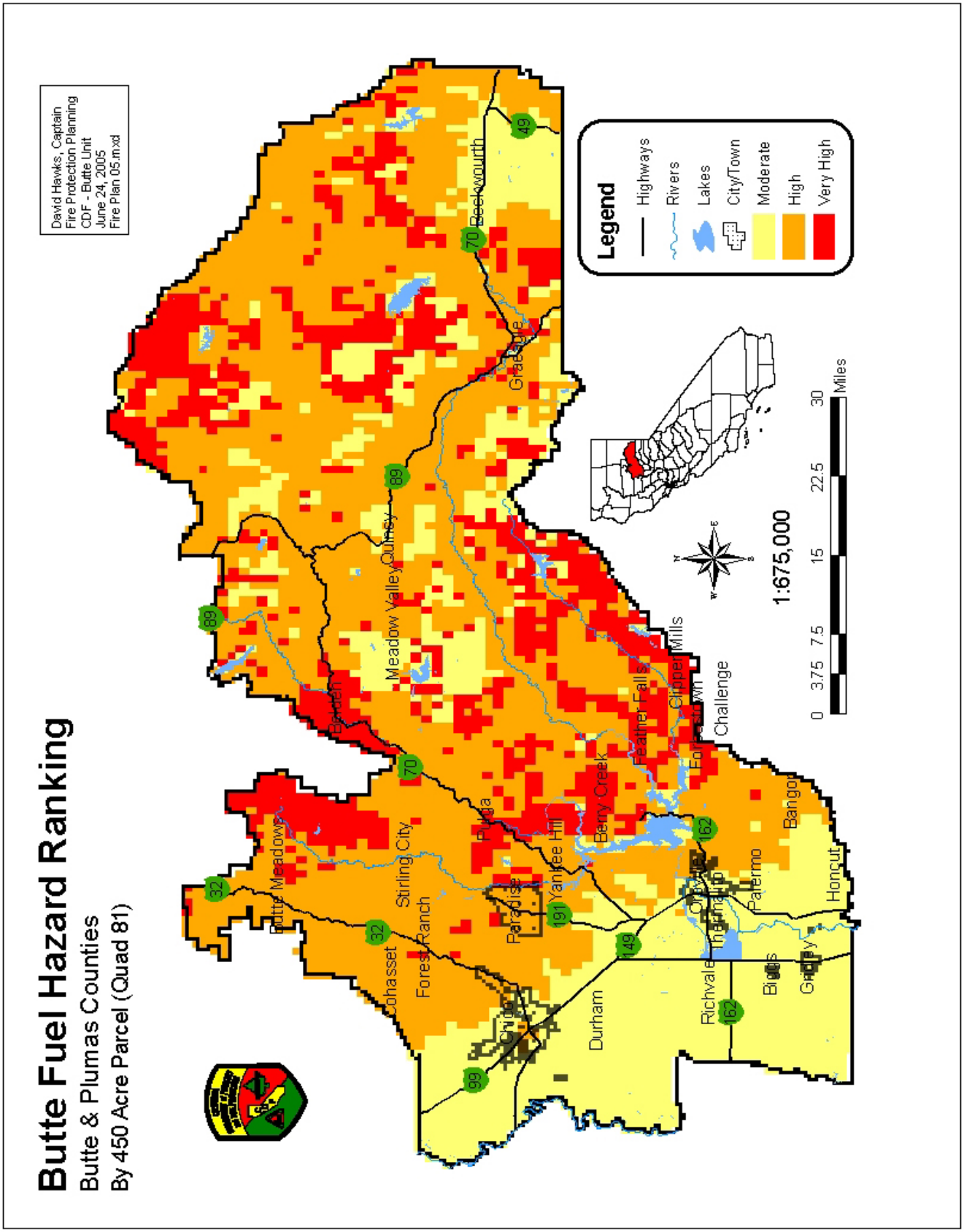
The total hazard rating includes not only hazard posed by surface fire, but also hazard by involvement of canopy fuels. The hazard ranking method includes this additional hazard component by adjusting the surface hazard rank according to the value of the ladder and crown fuel indices. Specifically, the surface hazard rank increases a maximum of one class in all situations where the sum of the ladder and crown fuel indices is greater than or equal to two.

The assessment method calculates expected fire behavior for unique combinations of topography and fuels under a given weather condition. While the BEHAVE Fire Behavior Prediction System (Andrews 1986) provides estimates of fire behavior under severe fire weather conditions for each of the FPBS fuel models located on six slope classes. Each fuel model combined with each slope class receives a surface hazard rank.

The potential fire behavior drives the hazard ranking. A rank is attributed to each Q81st (450 acre parcel) within the Butte Unit's state responsibility area (SRA). The ranking method portrays hazard ratings as moderate, high or very high. The map displaying the fuel hazard ranks within the Butte Unit can be used by stakeholders with interests in ecosystem management, fuels management, and pre-fire management as another tool to determine pre-fire management prescriptions.

Knowledge of fire behavior in a given fuel type is paramount in developing a community defense plan against wildfire. Fires in grass burn rapidly, but can be stopped by a roadway or plowed fire breaks. Fires in brush often burn with an intensity that prevents fire crews from safely applying water to the flame front. Timber fires can ignite new fires (called spot fires) miles ahead of the main blaze, hampering control efforts. Only wide scale pre-fire management programs can reduce the potential of a wildfire catastrophe.

Another issue related to fuels that are not in the FPBS is housing density. As can be seen on the population density map for Butte and Plumas Counties the introduction of humans has added fuel, in the form of structures, increasing the total fuel loading. Structural density was identified as a contributing factor in the loss of 2,900 structures, 25 deaths, and 1,600 acres consumed by the Tunnel Fire in Alameda County, October of 1991. Areas that show population destiny of 1,000 or more people per square mile are Paradise, Paradise Pines, East Oroville, and Palermo. The urbanization of California's wildland notwithstanding Butte and Plumas counties has resulted in a complex fire environment known as the "Urban Interface" or I-Zone making it extremely difficult for fire protection agencies to protect life and property.


Butte Fuel Hazard Ranking
Butte & Plumas Counties
By 450 Acre Parcel (Quad 81)
David Hawks, Captain
Fire Protection Planning
CDF - Butte Unit
June 24, 2005
Fire Plan 05.mxd
Legend
Highways
Rivers
Lakes
City/Town
Moderate
High
Very High
1:675,000
0 3.75 7.5 15 22.5 30
Miles
Beckwourth
Graeagle
Meadow Valley
Quincy
Belden
Butte Meadows
Stirling City
Forest Ranch
Cohasset
Chico
Durham
Paradise
Pulga
Yankee Hill
Berry Creek
Feather Falls
Clipper Mills
Challenge
Forbestown
Oroville
Thermalito
Palermo
Bangor
Honcut
Richvale
Biggs
Gridley
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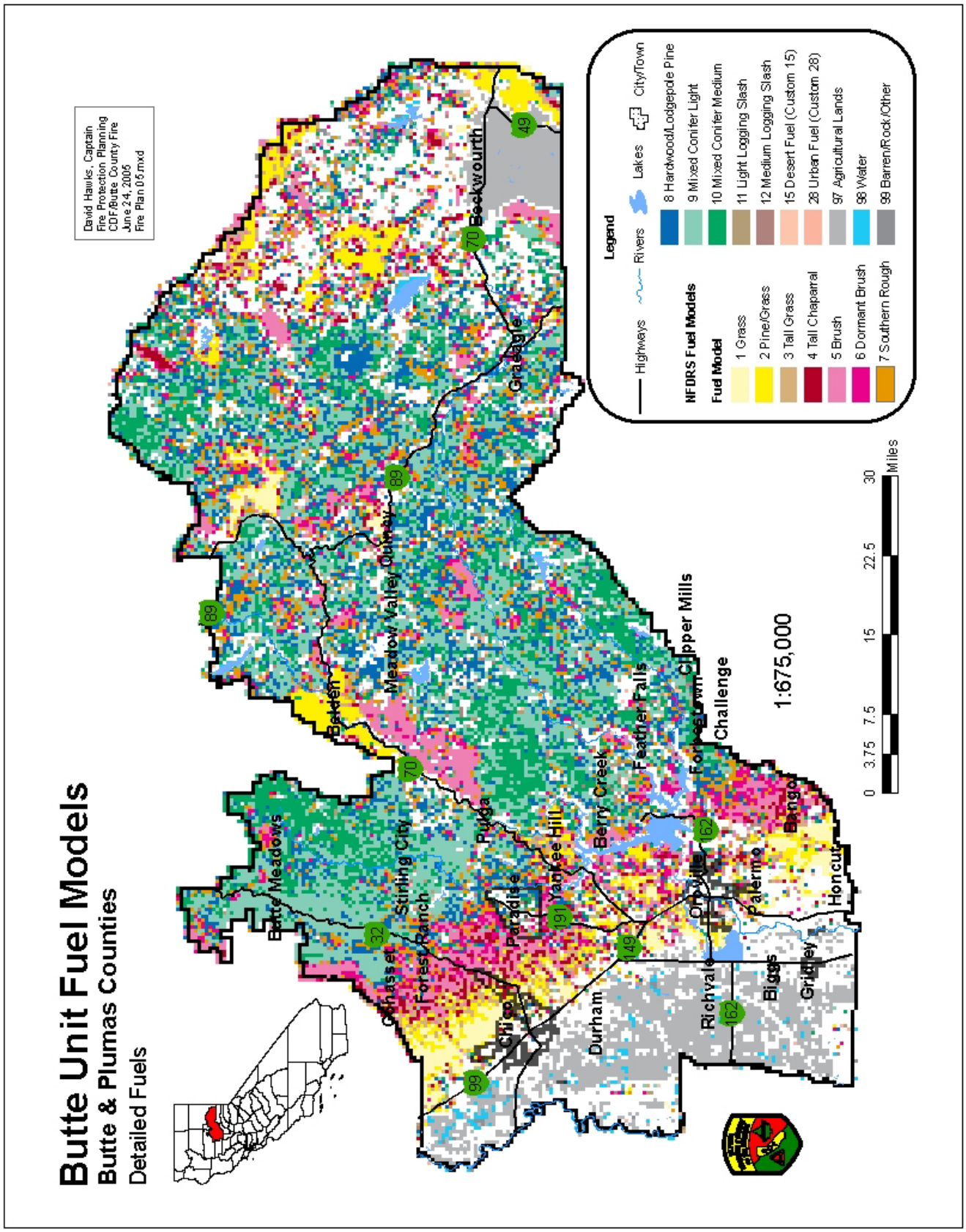
Butte Unit Fuel Models
Butte & Plumas Counties
Detailed Fuels
David Hawks, Captain
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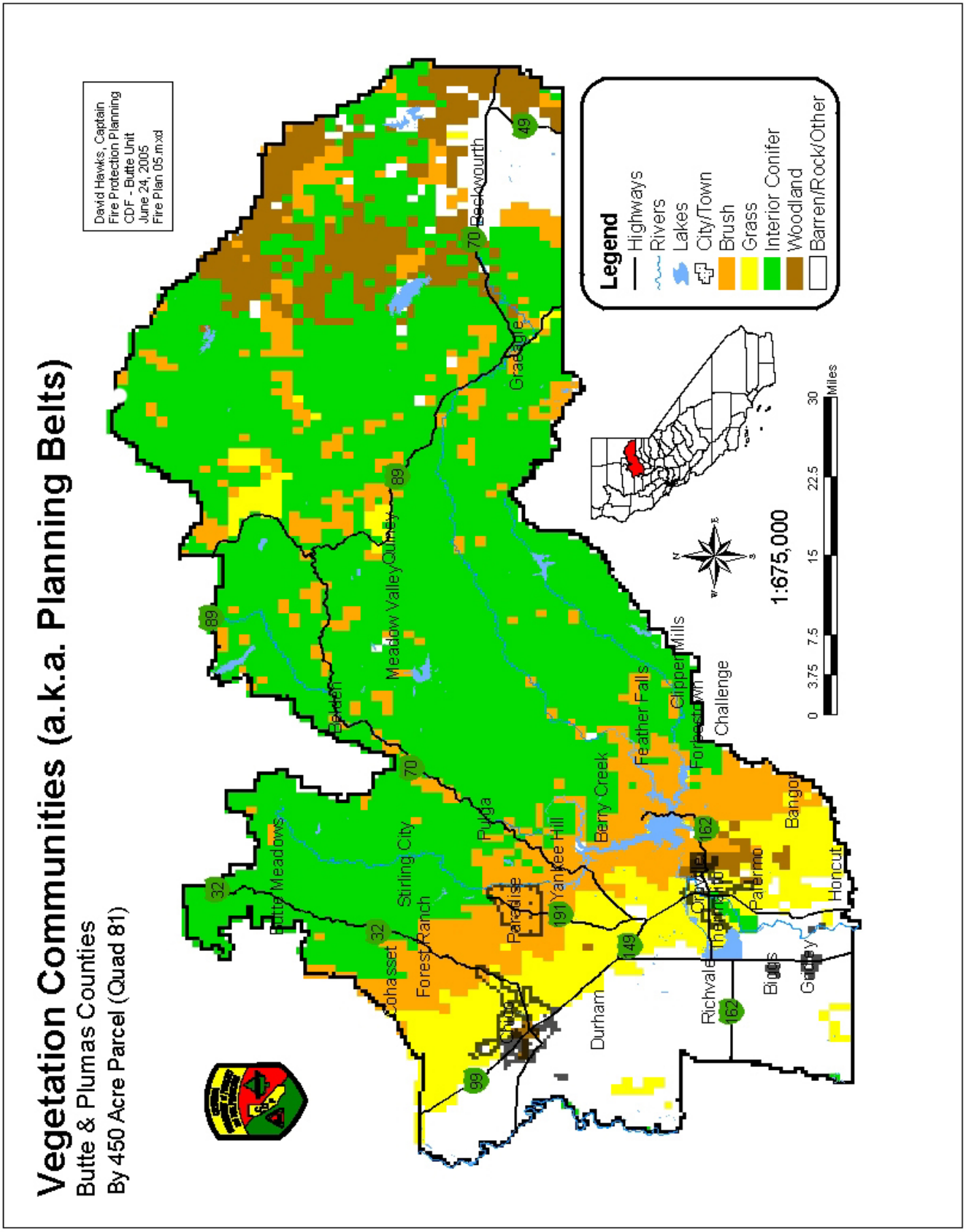
CDF/Butte County Fire
June 24, 2005
Fire Plan 05.mxd
Legend
Highways
Rivers
Lakes
City/Town
NFDRS Fuel Models
Fuel Model
1 Grass
2 Pine/Grass
3 Tall Grass
4 Tall Chaparral
5 Brush
6 Dormant Brush
7 Southern Rough
8 Hardwood/Loadgepole Pine
9 Mixed Conifer Light
10 Mixed Conifer Medium
11 Light Logging Slash
12 Medium Logging Slash
15 Desert Fuel (Custom 15)
28 Urban Fuel (Custom 28)
97 Agricultural Lands
98 Water
99 Barren/Rock/Other
1:675,000
0 3.75 7.5 15 22.5 30
Miles
Beckwourth
Graeagle
Meadow Valley
Quincy
Belden
Butte Meadows
Stirling City
Forest Ranch
Paradise
Pulga
Yankee Hill
Berry Creek
Feather Falls
Clipper Mills
Challenge
Forbestown
Oroville
Palermo
Bangor
Honcut
Chico
Durham
Richvale
Biggs
Gridley
49
70
89
32
191
149
162
99


Vegetation Communities (a.k.a. Planning Belts)
Butte & Plumas Counties
By 450 Acre Parcel (Quad 81)
David Hawks, Captain
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